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PROCEEDINGS

OF

THE ROYAL IRISH ACADEMY.

1836—1837. No. 1.

October 24, 1836.

REV. B. LLOYD, D.D., Provost, T.C.D., President, in the Chair.

REV. Edward Marks, Frederick Darley, Esq., Rev. John A. Bolster, and Rev. James S. Reid, D.D., were elected Members of the Academy.

A paper was read, entitled "Contributions to the History of Pyroxylic Spirit, and the derived Combinations." By Robert J. Kane, M.D. M.R.I.A., Professor of Natural Philosophy in the Royal Dublin Society.

In this paper Professor Kane stated that he had repeated the analysis of pyroxylic spirit and of methylic ether, and found the composition given by Dumas for these bodies to be perfectly correct. He likewise re-examined the pyroxylic spirit, described and analysed by Liebig, having been presented with a specimen of the original spirit for that purpose by Professor Liebig. The result of his experiments is, that the pyroxylic spirit of Liebig is quite distinct from that of Dumas; and that both of these chemists were right in the analyses which they published.

By treating the pyroxylic spirit of Dumas (methylic alcohol) with peroxide of manganese and sulphuric acid, there is obtained a light colourless liquor boiling at 103° Fahrenheit.

It is composed of $C_4H_{10}O_3$. It may be considered as tritoxide of ethyl AE. O. or as corresponding in the methylene series to the acetal in the alcoholic, being a tribasic formomethylic ether; thus,

$3 \times C_6H_6O = C_6H_{18}O_3$ three atoms methylic ether.
$C_2H_2O_3$ one atom formic acid.

$C_8H_{20}O_6 \div 2 = C_4H_{10}O_3$.

the density of its vapour is 2,45.

The pyroxylic spirit of Liebig, $C_4H_{10}O_2$, is considered by Professor Kane to be not a deutoxide of ethyl, but a tribasic ether, containing the methylene aldehyd. Thus,

$3 \times C_2H_6O = C_6H_{18}O_3$ three atoms methylic ether.
C_2H_2O methylic aldehydene.

$C_8H_{20}O_4 \div 2 = C_4H_{10}O_2$.

The analysis of the heavy oily liquor obtained by the action of chlorine on methylic alcohol, as pointed out by Dumas, is given by Professor Kane as leading to the formula $C_6Cl_3H_4O_2$. The products of its decomposition by bases will form part of a subsequent paper.

An oil which accompanies pyroxylic spirit gave for its composition $C_{20}H_{30}O$. isomeric with the resinain of Fremy.

Professor Kane has found pyroxylic spirit to form a compound with chloride of calcium crystallizing in plates, (hexagonal,) consisting of one atom of chloride of calcium with two of the pyroxylic spirit.

A paper was also read, "On the laws of Reflexion from Metals." By James Mac Cullagh, M. R. I. A., Professor of Mathematics in the University of Dublin.

The author observes that the theory of the action of metals upon light is among the *desiderata* of physical optics, whatever information we possess upon this subject being

derived from the experiments of Sir David Brewster. But, in the absence of a real theory, it is important that we should be able to represent the phenomena by means of empirical formulæ; and, accordingly, the author has endeavoured to obtain such formulæ by a method analogous to that which Fresnel employed in the case of total reflexion at the surface of a rarer medium, and which, as is well known, depends on a peculiar interpretation of the sign $\sqrt{-1}$. For the case of metallic reflexion, the author assumes that the velocity of propagation in the metal, or the reciprocal of the refractive index, is of the form

$$m(\cos\chi + \sqrt{-1}\sin\chi);$$

without attaching to this form any physical signification, but using it rather as a means of introducing two constants (for there must be two constants, m and χ, for each metal) into Fresnel's formulæ for ordinary reflexion, which contain only one constant, namely, the refractive index.

Then if i be the angle of incidence on the metal, and i' the angle of refraction, we have

$$\sin i' = m(\cos\chi + \sqrt{-1}\sin\chi)\sin i, \tag{1}$$

and therefore we may put

$$\cos i' = m'(\cos\chi' - \sqrt{-1}\sin\chi')\cos i, \tag{2}$$

if
$$m'^4\cos^4 i = 1 - 2m^2\cos 2\chi\sin^2 i + m^4\sin^4 i, \tag{3}$$

and
$$\tan 2\chi' = \frac{m^2\sin 2\chi\sin^2 i}{1 - m^2\cos 2\chi\sin^2 i}. \tag{4}$$

Now, first, if the incident light be polarized in the plane of reflexion, and if the preceding values of $\sin i'$, $\cos i'$, be substituted in Fresnel's expression

$$\frac{\sin(i-i')}{\sin(i+i')},$$

for the amplitude of the reflected vibration, the result may be reduced to the form

$$a(\cos\delta - \sqrt{-1}\sin\delta), \tag{5}$$

if we put

$$\tan\psi=\frac{m}{m'}, \tag{6}$$

$$\tan\delta=\tan 2\psi\sin(\chi+\chi') \tag{7}$$

$$a^2=\frac{1-\sin 2\psi\cos(\chi+\chi')}{1+\sin 2\psi\cos(\chi+\chi')}. \tag{8}$$

Then according to the interpretation, before alluded to, of $\sqrt{-1}$, the angle δ will denote the *change of phase*, or the retardation of the reflected light; and a will be the amplitude of the reflected vibration, that of the incident vibration being unity. The values of m', χ', for any angle of incidence, are found by formulæ (3), (4), the quantities m, χ, being given for each metal. The angle χ' is very small, and may in general be neglected.

Secondly, when the incident light is polarized perpendicularly to the plane of reflexion, the expression

$$\frac{\tan(i-i')}{\tan(i+i')}$$

treated in the same manner, will become

$$a'(\cos\delta'-\sqrt{-1}\sin\delta'), \tag{9}$$

if we make

$$\tan\psi'=mm', \tag{10}$$

$$\tan\delta'=\tan 2\psi'\sin(\chi-\chi'), \tag{11}$$

$$a'^2=\frac{1-\sin 2\psi'\cos(\chi-\chi')}{1+\sin 2\psi'\cos(\chi-\chi')}; \tag{12}$$

and here, as before, δ' will be the retardation of the reflected light, and a' the amplitude of its vibration.

The number $\text{M}=\frac{1}{m}$ may be called the *modulus*, and the angle χ the *characteristic* of the metal. The modulus is something less than the tangent of the angle which Sir David Brewster has called the maximum polarizing angle. After two reflexions at this angle a ray originally polarized in a

plane inclined 45° to that of reflexion will again be plane polarized in a plane inclined at a certain angle ϕ (which is 17° for steel) to the plane of reflexion; and we must have

$$\tan\phi = \frac{a'^2}{a^2}. \qquad (13)$$

Also, at the maximum polarizing angle we must have

$$\delta' - \delta = 90°. \qquad (14)$$

And these two conditions will enable us to determine the constants M and χ for any metal, when we know its maximum polarizing angle and the value of ϕ; both of which have been found for a great number of metals by Sir David Brewster. The following table is computed for steel, taking $M = 3\frac{1}{2}$, $\chi = 54°$.

i	δ	δ'	a^2	a'^2	$\frac{1}{2}(a^2+a'^2)$
0°	27°	27°	.526	.526	.526
30	23	31	.575	.475	.525
45	19	38	.638	.407	.522
60	13	54	.729	.308	.5 8
75	7	98°	.850	.240	.545
85	2	152	.947	.491	.719
90	0	180	1.	1.	1.

The most remarkable thing in this table is the last column, which gives the intensity of the light reflected when common light is incident. The intensity *decreases* very slowly up to a large angle of incidence, (less than 75°,) and then increases up to 90°, where there is total reflexion. This singular fact, that the intensity decreases with the obliquity of incidence, was discovered by Mr. Potter, whose experiments extend as far as an incidence of 70°. Whether the subsequent increase which appears from the table indicates a real phenomenon, or arises from an error in the empirical formulæ, cannot be determined without more experiments. It should be observed, however, that in these very oblique incidences Fresnel's formulæ for transparent media do not represent the actual phenomena for such media, a great quantity

of the light being stopped, when the formulæ give a reflexion very nearly total.

The value of $\delta' - \delta$, or the difference of phase, increases from 0° to 180°. When a plane-polarized ray is twice reflected from a metal, it will still be plane-polarized if the sum of the values of $\delta' - \delta$ for the two angles of incidence be equal to 180°.

It appears from the formulæ that when the characteristic χ is very small, the value of δ' will continue very small up to the neighbourhood of the polarizing angle. It will pass through 90°, when $m m' = 1$; after which the change will be very rapid, and the value of δ' will soon rise to nearly 180°. This is exactly the phenomenon which Mr. Airy observed in the diamond.

Another set of phenomena to which the author has applied his formulæ are those of the coloured rings formed between a glass lens and a metallic reflector; and he has thus been enabled to account for the singular appearances described by M. Arago in the *Memoires d'Arcueil*, tom. 3, particularly the succession of changes which are observed when common light is incident, the intrusion of a new ring, &c. But there is one curious appearance which he does not find described by any former author. It is this. Through the last twenty or thirty degrees of incidence the first dark ring, surrounding the central spot which is comparatively bright, remains constantly of the same magnitude; although the other rings, like Newton's rings formed between two glass lenses, dilate greatly with the obliquity of incidence. This appearance was observed at the same time by Professor Lloyd. The explanation is easy. It depends simply on this circumstance, (which is evident from the table,) that the angle $180° - \delta'$, at these oblique incidences, is nearly proportional to $\cos i$.

As to the index of refraction in metals, the author conjectures that it is equal to $\frac{M}{\cos \chi}$.

Rev. Robert Gage exhibited specimens of Coal and Iron stone, recently found in Rathlin Island, on the North coast of Ireland.

DONATIONS.

Archæologia; or Miscellaneous Tracts relating to Antiquity, vol. xxvi. Presented by the President and Council of the Society of Antiquarians of London.

Copy of the Ordnance Survey of the County of Louth, in 27 sheets, presented by Lieut. Colonel Colby, R.E.

Philosophical Transactions of the Royal Society of London, for the years 1834, Part 2; 1835, Parts 1 and 2; and 1836, Part 1. Presented by the Society.

List of the Fellows of the Royal Society. By the same.

Memoir of the Fresh-water Limestone of Burdiehouse, in the neighbourhood of Edinburgh. By Samuel Hibbert, M.D., F.R.S.E. Also, *Analysis of Coprolites, and other Organic Remains, imbedded in the Limestone of Burdiehouse*. By Arthur Connell, Esq., F.R.S.E. Presented by Doctor Hibbert.

History of the Extinct Volcanos of the Basin of Neuweid, on the lower Rhine. By Samuel Hibbert, M.D., F.R.S.E. Presented by the Author.

Memoir on the Theory of Partial Functions. By John Walsh. Presented by the Author.

An Essay on the Origin and Nature of Tuberculous and Cancerous Diseases. By Richard Carmichael, M.D., M.R.I.A. Presented by the Author.

Transactions of the American Philosophical Society. Vol. v. Part 2. (New Series.) Presented by the Society.

Transactions of the Geological Society of London. Vol. iii. Part 3. (Second Series.) Presented by the Society.